APPENDIX D
RELIABILITY AND AVAILABILITY

The reference plant design presented in this section has reduced redundancy from reference designs produced in the past, yet maintains a high level of availability and reliability. Certain systems in a power plant have a history of causing plant outage or deratings. Table 1 gives the top 40 causes of outages and deratings for coal-fired power plants in the 400 to 599 MWe range.

This table is based on information compiled by the North American Electric Reliability Council, in a document titled, "Generating Availability Report 1985-1989." Each of the component availabilities is used to calculate the system availability. The system availabilities are then used to calculate plant availability. Plant availability is a measure of the amount of time a given plant is available to produce power. Through historic data from such sources as the North American Electric Reliability Council, and system availability calculations, the availability for a modern pulverized coal-fired electric power plant is expected to be in the range of 83 to 86 percent, considering planned and forced outages and deratings.

The information from the "Generating Availability Report" and other availability information was utilized in developing system block diagrams to determine the effects of reduced redundancy on system availability. System block diagrams for the coal handling system are included at the end of Appendix D. In Figure 1, a traditional utility type system with a majority of the system having redundant components is illustrated. Figure 2 shows a system as it would be designed today, with the redundancy reduced; however, some items are oversized to provide a margin that would allow the plant to repair a piece of equipment without losing generating capability. In addition, critical components with long "mean time to repair" times are still redundant (i.e., crushers) to maintain an acceptable availability rate. The differential in availability between Figure 1 and Figure 2 is 0.68 percent.

In Figure 3, a low capital cost design is analyzed. This design has eliminated the redundant equipment and reduced availability by 8.88 percent. This is a significant reduction in availability and would not be a recommended design. Major systems can be analyzed by this method to determine the optimum design, considering both capital cost and availability.

Table 1
OUTAGES AND DERATINGS FOR COAL-FIRED POWER PLANTS

System	Mean Time Between Failure, Hours	Mean Down Time, Hours	Availability
Boiler Overhaul	12,514	608.47	0.953631
Major Turbine Overhaul	36,500	850.05	0.977241
Boiler Inspections	33,692	448.14	0.986874
Furnace Wall	4,710	49.91	0.989515
Inspection	87,600	452.25	0.994864
First Reheater	12,167	52.98	0.995664
Electrostatic Precipitator Problems	3,490	14.20	0.995948
Economizer	13,273	40.86	0.996931
Electrostatic Precipitator Fouling	11,526	30.12	0.997394
Second Superheater	15,927	40.28	0.997477
Feedwater Pump	4,949	12.11	0.997559
First Superheater	21,366	49.91	0.997669
Major Overhaul	438,000	950.96	0.997834
Rotor Windings	292,000	707.01	0.997585
Boiler Water Condition (not feedwater water quality)	1,321	2.63	0.998013
Cyclone Furnace (in cyclone area only)	41,714	80.77	0.998067
Main Transformer	25,028	47.82	0.998093
Opacity - Fossil Steam Units	1,665	2.91	0.998255
High Pressure Heater Tube Leaks	8,848	14.43	0.998372
Vibration of the Turbine Generator Unit	13,273	19.40	0.998541
Second Reheater	38,087	55.15	0.998554
Pulverizer Mills	1,884	2.65	0.998595
Other Catastrophe	438,000	599.68	0.998633
Primary Air Heater (regenerative)	19,909	24.88	0.998752
Stator Windings, Bushings and Terminals	175,200	213.84	0.998781
Other Tubes	62,571	73.23	0.998831
Forced Draft Fans	30,207	35.87	0.998814
Other Steam Turbine Problems	32,444	38.81	0.998805
Generator Vibration	43,800	52.07	0.998813
Buckets or Blades	292,000	305.42	0.998955
Feedwater Pump Drive - Steam Turbine	8,588	9.48	0.998897
Boiler, Miscellaneous	12,696	13.98	0.9989
Condenser Tube Leaks	8,588	8.59	0.999001
Boiler Recirculation Pumps	25,028	23.94	0.999044
Primary Air Heater Fouling (regenerative)	27,375	25.74	0.999061
Bearings	58,400	57.07	0.999024
Combustion/Steam Condition Controls	12,167	11.29	0.999073
Reheat Steam Piping up to Turbine Stop Valves	219,000	210.92	0.999038
Induced Draft Fans	13,905	12.54	0.999099

Assumptions

This reference plant design is based on the following assumptions:

- Initially a single unit facility is to be constructed including a single pulverized coal-fired boiler connected to a single turbine generator, with an FGD system integrated into the facility.
- Provisions have been make in the initial unit site layout arrangement to provide for the addition of a future second unit and the necessary support facilities.
- The circulating water heat sink is a mechanical draft evaporative cooling tower.
- Makeup and potable water for plant use is filtered and treated on site.
- Plant and sanitary wastes are held and treated on site.

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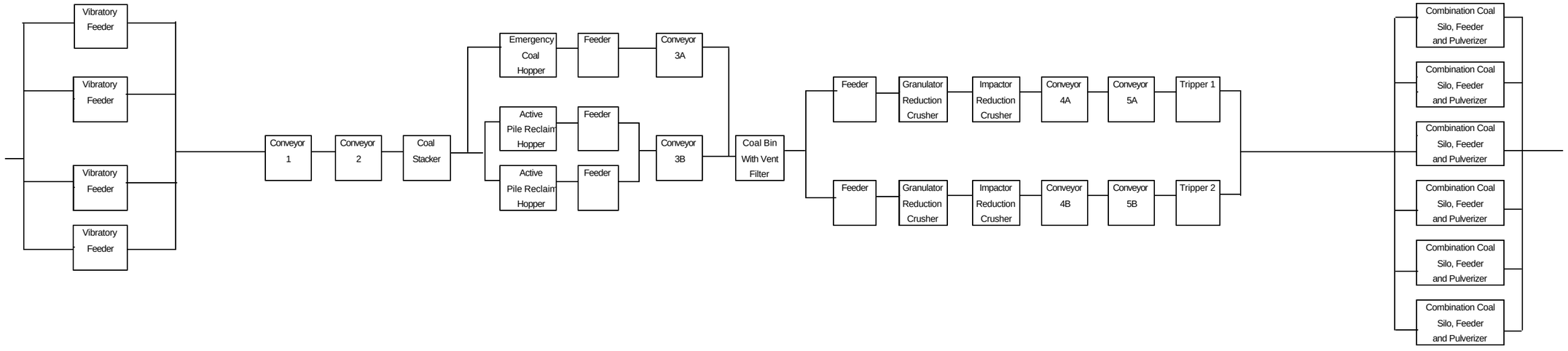
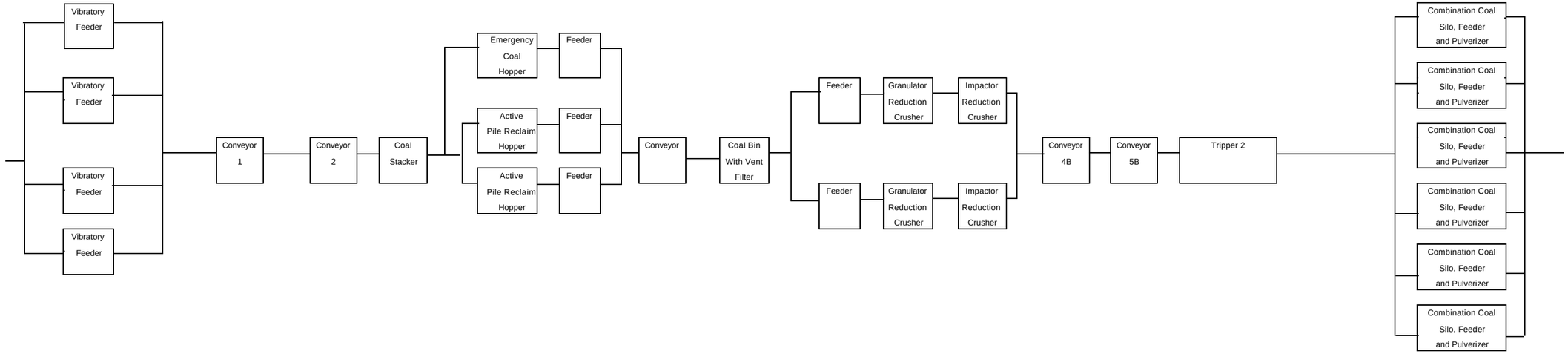
Figure 1
Utility Design Availability Analysis (Conceptual)
Coal Handling System Block Diagram



	Feeder		Conveyor	Conveyor	Coal Stacker	Hopper	Feeder	Conveyor	Bin	Feeder	Crusher	Crusher	Conveyor	Conveyor	Tripper	Coal Silo w/Vent Filter	Feeder	Pulverizer
MTBF, hrs	377.5		17520	17520	26280	12500	377.5	17520	2190	377.5	8760	8760	17520	17520	1752	91100	377.5	1884
MTTR, hrs	24		18	18	10	74.24	24	18	8.53	24	133	133	18	18	9	12.45	24	2.65
Availability of each component	0.940224		0.999	0.999	0.99962	0.9941	0.94	0.999	0.99612	0.94	0.98504	0.98504	0.999	0.999	0.9949	0.999863356	0.940224159	0.998595394
						Avail. of redundant active pile and	0.99573									Avai of each Combination Coal Silo, Feeder,	0.938775219	
Availability of redundant equipment	0.999184	Need 2 out of 4 Feeders operating				Avail. of active/ emergency reclaim system	0.99965			Avail. of redundant crusher trains	0.991					Need 4 out of 6 trains operating	0.996011865	

Availability of Coal Handling System	0.9798061
97.98% Available	

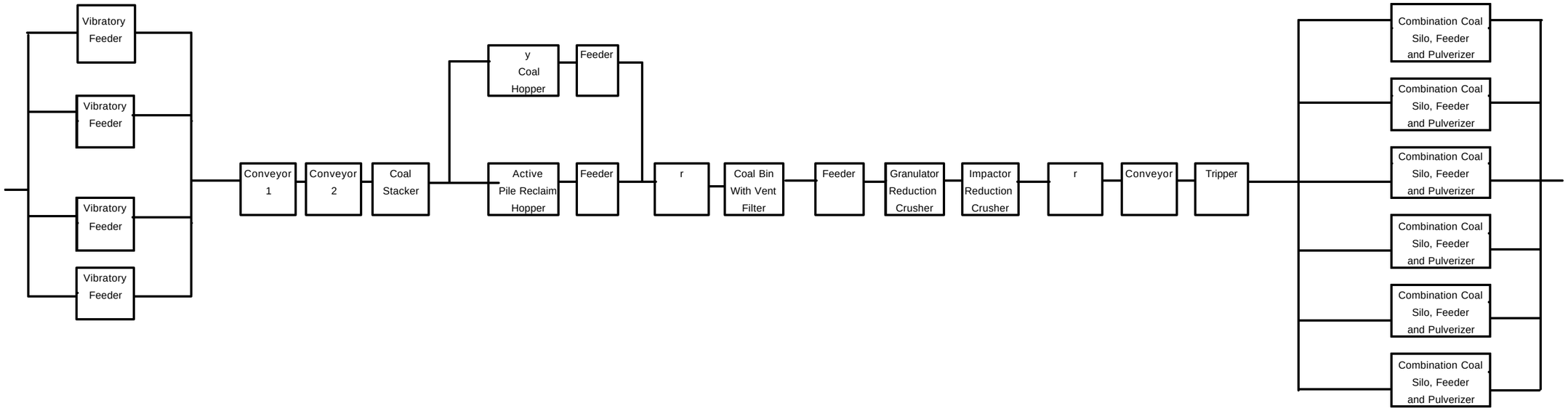
Figure 2
Non Utility Design Availability Analysis (Conceptual)
Coal Handling System Block Diagram



	Feeder		Conveyor	Conveyor	Coal Stacker	Hopper	Feeder	Conveyor	Bin	Feeder	Crusher	Crusher	Conveyor	Conveyor	Tripper	Coal Silo w/Vent Filter	Feeder	Pulverizer
MTBF	377.5		17520	17520	26280	12500	377.5	17520	2190	377.5	8760	8760	17520	17520	1752	91100	377.5	1884
MTTR	24		18	18	10	74.24	24	18	8.53	24	133	133	18	18	9	12.45	24	2.65
Availability of each	0.94022		0.999	0.999	0.99962	0.9941	0.94	0.999	0.99612	0.94	0.98504	0.98504	0.999	0.999	0.994889267	0.999863356	0.940224159	0.999
															Avail of each combination Coal Silo, Feeder, Pulverizer train	0.938775219		
						Avail. of active/ emergency reclaim system	0.99972			Avail. of redundant crusher train	0.992							
Availability of redundant equipment	0.99918	Need 2 out of 4 Feeders operating													Need 4 out of 6 operating	0.996011865		

Availability of Coal Handling System	**0.97303**
97.30% Available	

Figure 3
Low Capital Cost Design Availability Analysis (Conceptual)
Coal Handling System Block Diagram



	Feeder		Conveyor	Conveyor	Coal Stacker		Hopper	Feeder	Conveyor	Bin	Feeder	Crusher	Crusher	Conveyor	Conveyor	Tripper		Coal Silo w/Vent Filter		Feeder	Pulverizer
MTBF	377.5		17520	17520	26280		12500	377.5	17520	2190	377.5	8760	8760	17520	17520	1752		91100		377.5	1884
MDT	24		18	18	10		74.24	24	18	8.53	24	133	133	18	18	9		12.45		24	2.65
Availabvility of each component	0.94022		0.99897	0.99897	0.99962		0.9941	0.94	0.999	0.99612	0.9402	0.98504	0.98504	0.999	0.99897	0.9949		0.999863		0.9402	0.998595394
						Avail. of active/ emergency reclaim system	0.99573										Avail. of each combination Coal Silo, Feeder, Pulverizer train	0.938775			
Availability of redundant equipment	0.99918	Need 2 out of 4 Feeders operating															Need 4 out of 6 trains operating	0.996012			

Availablity of Coal Handling system	**0.89102**
89.10% Available	